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Sarcolobus cambogensis (Marsdenieae, Asclepiadoideae, Apocynaceae): A new rheophytic shrub from Cambodia

ELIZABETH E. MCHONE[1], HYOSIG WON[2] & TATYANA LIVSHULTZ[1,3, 4]
[1]*Department of Biodiversity, Earth & Environmental Science, Drexel University, 3141 Chestnut St., Philadelphia PA 19104 USA*
[2]*Department of Biological Science, Daegu University, Gyungsan, Gyungbuk 712–714, Korea (R.O.K.)*
[3]*Botany Department, Academy of Natural Sciences of Drexel University, 1900 Benjamin Franklin Pkwy., Philadelphia PA 19103 USA*
[4]*Author for correspondence: Tatyana Livshultz, tl534@drexel.edu*

Abstract

A new species of Apocynaceae from Cambodia, *Sarcolobus cambogensis* McHone & Livsh., is described and illustrated. Specimens of the new species, all from the Central Cardamom Region, Koh Kong Province, have morphological characters diagnostic of *Sarcolobus* (truncate stylehead apices and oblong corpuscula). Like *Sarcolobus luzonensis* (Warb.) P.I. Forst. and *S. borneensis* (van Steenis) P.I. Forst., *S. cambogensis* has a rheophytic, shrubby habit, unusual in both *Sarcolobus* and Apocynaceae. It differs from the latter two species in its broader leaves, larger corona, and wider caudicles.

Introduction

The flora of Cambodia has been studied as part of the Indochinese flora, and floristic surveys were mainly conducted by French botanists, such as C. Thorel, L. Pierre, F.J. Harmand, Geoffray, A. Chevalier, and E. Poilane in the late 19th and early 20th centuries. Their work resulted in the compilation of seven volumes of *Flore Générale de L'indo-Chine* (Lecomte *et al.* 1907–1951), where ca. 8,000 species were described for Cambodia, Vietnam, and Laos. Dy Phon (1982) reported 2,308 out of these 8,000 species for Cambodia, although current estimates range as high as 5,000 species (Chassagne & Hul 2014). Since 1984, 39 new taxa of vascular plants with distributions in Cambodia have been named (IPNI, 2012).

The interior of the central Cardamom region in southwestern Cambodia was almost completely uncollected until the last two decades when collaborative international and national survey teams began the exploration of the biota (Daltry 2008, Grismer 2008). The new species here described was collected during surveys of the dry dipterocarp (240–400 m) and lowland evergreen (400–1,000 m) forests of the Central Cardomom, Koh Kong area (forest classification according to Meng *et al.* 2000), growing in the channels of seasonally fast-flowing rivers, swollen annually by the May to October monsoon (Fig. 1, 2A).

For Apocynaceae subfamilies Apocynoideae and Rauvolfioideae, all Cambodian species will be covered in the forthcoming treatment for the *Flore du Cambodge, du Laos et du Vietnam* (Middleton, in press).

For subfamilies Asclepiadoideae, Secamonoideae, and Periplocoideae, *Flore Générale de L'indo-Chine* was the last truly comprehensive floristic treatment for Cambodia (Lecomte 1912). Since then, several researchers have produced floristic treatments of these subfamilies for adjacent countries including 1) checklists and floras for Thailand and Vietnam (Craib & Kerr 1951, Hô 1993); 2) floristic studies of *Dischidia* Brown (1810b: 461) (from Laos and Vietnam), *Cynanchum* Linnaeus (1753: 212), and *Vincetoxicum* Wolf (1776: 130) (in Malesia) (Livshultz *et al.* 2005, Liede 1999); and 3) many new species of *Hoya* Brown (1810b: 459), including five from Vietnam (Tran *et al.* 2011, Bach *et al.* 2011, Pham & Averyanov 2012, Rodda *et al.* 2013), five from Thailand (Thaithong 2001, Kidyoo & Thaithong 2007, Kidyoo & Watthana 2012, Rodda & Juhonewe 2012a, Kidyoo 2013), and one from Laos (Rodda & Juhonewe 2012b). A recent photographic guide to Cambodian plants included 10 species from these three subfamilies (Leti *et al.* 2013).

Placement of the new species in Asclepiadoideae tribe Marsdenieae is unambiguous; it has the diagnostic characters of the tribe including contorted corolla lobes in the bud, hyaline anther apical connective appendages without a basal

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constriction, pollinaria with pollinia acropetal to the corpuscle *in situ*, pollinia without a pellucid margin, and ovaries without evident styles (Bruyns & Forster, 1991, Omlor 1998, Endress & Bruyns 2000, Meve & Liede 2004). Generic placement of the species is much more problematic. Marsdenieae are overdue for a generic revision. The current concept of *Marsdenia* Brown (1810b: 460) is extremely broad and vague, making it difficult to place new species to genera (Forster 1995, Omlor 1998). Forster has broadened the concept of *Marsdenia* more than any, however, he maintained *Sarcolobus* Brown (1810a: 23) as distinct (Forster 1995). He identified capitate gynostegia, styleheads with apical papillae, geniculate caudicles, and oblong corpuscles as the key diagnostic characters of *Sarcolobus* (Forster 1991).

FIGURE 1. Distribution of *Sarcolobus cambogensis* in Koh Kong province, Cambodia. Map generated with SimpleMappr (Shorthouse, 2010).

Sarcolobus, an endemic of tropical Asia and Australasia, has been the subject of a number of recent taxonomic studies. Rintz (1980) revised *Sarcolobus*, reducing 17 names to 4 species, all restricted to coastal and mangrove habitats with ellipsoid or ovoid fruits, and reduced or absent seed comas. Rintz (1980) recognized the rheophytic *Dorystephania* (Warb.) in Perkins (1904: 123), with two species, as a distinct genus intermediate between *Sarcolobus* and *Pentasacme* Don (1837: 159). Later, Forster (1993) transferred the two *Dorystephania* species to *Sarcolobus*. *Pentasacme* is not closely related at all; it belongs to Ceropegieae, not Marsdenieae (Bruyns & Forster, 1991, Meve & Liede 2002). It is understandable why Rintz (1980) thought that the species of *Dorystephania*, now treated as *Sarcolobus borneensis* (van Steenis 1981: 201) Forster (1993: 355) and *S. luzonensis* (Warb. in Perkins 1904: 123) Forster (1993: 352), were part of a "hybrid genus" between *Sarcolobus* and the rheophytic *Pentasacme*—those two species, endemic to Borneo and the Philippines, respectively, have rheophytic habits (like *Pentasacme*) but *Sarcolobus*-like leaves and flowers. Forster (1993) suggested that the rheophytism of these two species is apomorphic since most Marsdenieae species are twining shrubs and lianas.

Further broadening the concept of *Sarcolobus*, Forster (1991, 1992) also transferred species from *Marsdenia*, *Gymnema* Brown (1810a: 22), *Papuastelma* Bullock (1965: 202) (= *Astelma* Schltr., nom. illeg.) and *Tylophora* Brown (1810a: 17). In Forster's concept, *Sarcolobus* is broader in habitat (lowland rain forests, tropical montane forests, open woodlands and heaths, estuarine and forested wetlands), habit (vines and shrubs), gynostegium shape (capitate to cylindrical to conic), caudicle shape (prominently to only obscurely geniculate), and fruit and seed morphology (fusiform to ovoid follicles and ovate, oblong, or flat seeds with or without a coma). This broader *Sarcolobus* is harder to distinguish from *Marsdenia* but species can be placed here by a combination of some of the diagnostic floral characters (papillate styleheads, capitate gynostegia, narrow-oblong corpuscles, and/or geniculate caudicles) (Forster 1991, 1992, 1993). Furthermore, the stylehead and gynostegium consistently have truncate apices.

Omlor (1998) also broadened *Sarcolobus* by placing the monotypic Philippine genus *Quisumbingia* (Schlechter 1915: 544) Merrill (1936: 33) in synonymy. But he disputed some of Forster's broadening of *Sarcolobus*, transferring or returning five Papuasian species to *Marsdenia* (pp. 134–5). A well-sampled phylogenetic analysis is required to clarify the delimitation of *Sarcolobus*, but a preliminary molecular analysis supports the inclusion of the new species in *Sarcolobus* (Livshultz *et al.* in prep).

Rheophytism, or a habit adapted to life in or at the margins of fast-flowing streams and rivers, is rare in Apocynaceae *sensu lato* (van Steenis 1981) (Fig. 2). It is, presumably, a difficult habitat to occupy given the frequency of floods that can uproot plants and strip leaves and bark. Common adaptations of rheophytic plants include a shrubby habit,

narrow leaves that decrease water resistance, highly developed root systems, and seeds that float (van Steenis 1981).

Here we describe a new rheophytic species of *Sarcolobus* from the Central Cardomom Region, Koh Kong Province, Cambodia, and compare it to previously described rheophytic and/or shrubby *Sarcolobus* species from the Philippines, Borneo, and Fiji.

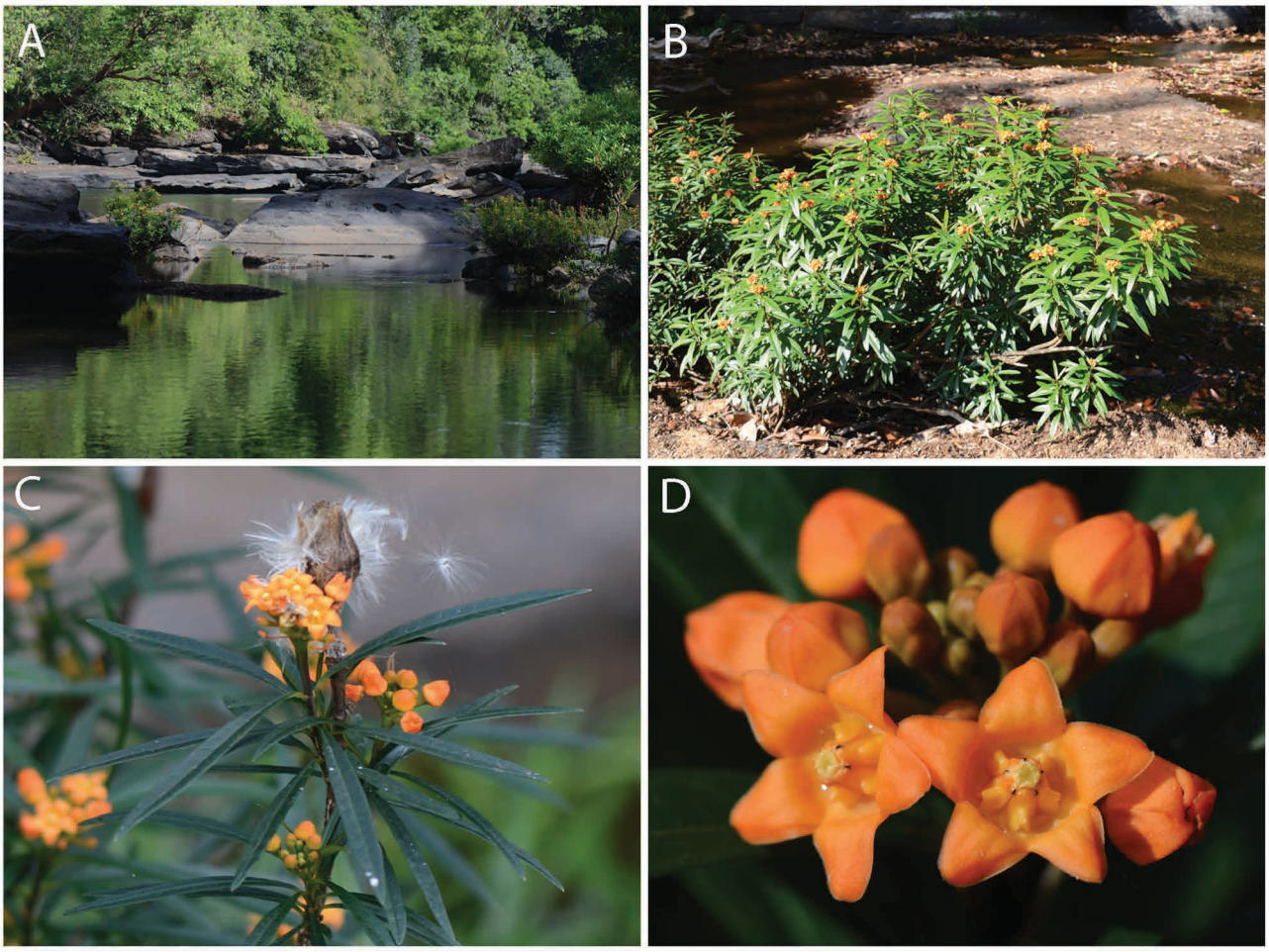

FIGURE 2. *Sarcolobus cambogensis* habitat and growth form. **A.** riparian habitat, **B.** shrubby habit, **C.** open follicle releasing seeds, and **D.** orange flowers (photographs: Hyosig Won from type locality)

Materials & Methods

The descriptions presented here are based on study of herbarium specimens of *Sarcolobus cambogensis* (A, E, P, PH), *S. borneensis* (A), and *S. luzonensis* (A), digital images of the type of *S. stenophyllus* (NY), and illustrations and descriptions of these and other species of *Sarcolobus* (Craib & Kerr 1951, Rintz 1980, van Steenis 1981, Forster 1991, 1992, 1993, Hô 1993, Omlor 1998). Measurements of vegetative and reproductive structures were made on six specimens of the new species and compared to the other three shrubby species. Photographs taken by Hyosig Won and Mathieu Leti and field observations made by Hyosig Won also informed the description.

Larger measurements were taken with a Marathon Electronic Digital caliper, finer measurements were taken in Leica Application Suite V4.4 from digital images made with a Leica M165 C dissecting microscope. Stem diameters were measured from shoots with mature bark and internode lengths from shoots with fully-expanded leaves. Those same leaves were measured. Flower measurements came from one hydrated flower of each specimen possessing intact, mature inflorescences. Flowers were rehydrated in deionized water brought to 100°C. Peduncle lengths were measured from the uppermost vegetative node, to the lowermost inflorescence bract. Flower length was measured from the base of the calyx to the apex of the gynostegium and width at the widest point of the corolla, between the tips of the corolla lobes. Fruit pedicel lengths were measured from the node on the infructescence to the follicle base. Photographs of all microscopic structures were taken with Leica Application Suite V4.4. Illustrations of reproductive parts were made from these microphotographs, and the illustration of the plant habit was rendered from a photograph (Fig. 2C).

Taxonomy

Family APOCYNACEAE Juss.

Sarcolobus cambogensis McHone and Livsh. *sp. nov.* (Figs. 1–4)

Similar to *Sarcolobus borneensis* (van Steenis) P.I.Forst. and *Sarcolobus luzonensis* (Warb.) P.I.Forst. in shrubby, rheophytic habit and narrow leaves, distinguished from them by its comparatively broader leaves, prominent staminal coronas, and wider caudicles.

Type:—CAMBODIA. Koh Kong: ca. 6 km SW from the Central Cardamom Protected Forest Thmor Bang Station, 11°39'39.2"N 103°23'58.5"E, 342 m, 6 January 2012, *H. Won et al. 6398* (holotype PH!; isotypes DGU!, KB!).

*Plant*s erect rheophytic shrub to 60 cm high. *Latex* white. *Stems* woody, terete, 3–6 mm in diameter, slightly tomentulose, glabrescent; internodes up to 15 mm long. *Stipular colleters* paired, on opposite edges of petiole base, ca. 300 × 200 µm, triangular, senescent. *Leaves* opposite, petiolate; *petiole* 3–10 × 0.6–1.4 mm; *lamina* linear-lanceolate, 33–87 × 5–13 mm, discolorous, glabrescent, margins weakly revolute and weakly undulate; adaxial surface medium to dark green, venation obscure, with 1–2 laminar colleters at base, ca. 400 × 200 µm, triangular, senescent; abaxial surface pale green, venation visible, pinnate, 12–16 secondary vein pairs diverging at a ca. 45° angle to the primary vein, brochidodromous; apex weakly apiculate, base attenuate. *Inflorescence* terminal, appearing axillary when overtopped by axillary shoot, umbelliform (early) to racemiform (late) cymes up to 45 mm long with up to 8–10 flowers at apex, lower portion of older rachises with a spiral of pedicel scars and persistent subtending bracts; unbranched or rarely two-branched; *bracts* triangular, 0.9–2.3 × 0.4–1.2 mm, with sparse indumentum, lower-most bract slightly larger, ca. 3 mm below the phylotactic spiral; *peduncle* 4–9.7 × 1.2–2.1 mm. *Flowers* 3.7–6.6 × 4.7–9.5 mm, subtended by paired bracts, *pedicels* 5–6.5 × 0.6–1.3 mm, with scattered indumentum; *sepals* 5, imbricate, lanceolate, basally connate, 1.6–3.4 × 1.5–2.3 mm; *colleters* 5–11, in sinuses of sepals (rarely opposite sepals), 1–4 in each sinus, 200–400 × 80–250 µm. *Corolla* subrotate to campanulate, orange to yellow-orange, glabrous except for sparse indumentum on adaxial petal tips; *tube* 1.9–3 × 3.3–6.5 mm; *lobes* lanceolate, 2–3.8 × 0.9–3.2 mm, contorted to the right in bud; *corolline corona* absent. *Gynostegium* yellow, glabrous, conic, 3.3–3.6 × 2.3–3.8 mm, sessile, apex truncate. *Anthers* oblong, 1.5–1.7 × 0.3–0.5 mm; *apical connective appendages* triangular, hyaline, 0.5–0.8 × 0.5–0.7 mm, apex obtuse; *guide rails* 1.3–2 × 0.6–1 mm, basally divergent. *Staminal corona* of 5 prominent lobes attached near base of gynostegium, lobes A-frame shaped, triangular in longitudinal section, basally sulcate, 1.3–2 × 0.6–1 mm. *Pollinaria* 440–570 × ca.600 µm; *corpusculum* oblong, brown, deep fissure running the length, 380–420 × 130–190 µm; *caudicles* yellow-green, flattened, 130–230 × 60–150 µm, weakly geniculate; *pollinia* ellipsoid, 260–390 × 170–250 µm. *Gynoecium* superior, *stylehead* turbinate, 5-angled, ca. 2.3 × 2.4 mm, apex truncate, not papillate, ovaries ca. 1.5 mm long. *Fruit pedicel* 6–18 × 2–5 mm; *follicles* fusiform, abruptly narrowed at the base, upright, solitary or paired on each pedicel, brown at maturity, striate, ca. 40 × 4–11 mm. *Seed* ovate (almost trullate), with flattened margins, brown, 3.9–6.3 × 1.9–3.2 mm; coma white, wispy, 8–13.9 mm long.

Phenology:—*Flowers present* December–February; *fruits present* November–February and May.

Distribution:—Tatai River, Koh Kong province, Cambodia.

Ecology:—A rheophyte of seasonally flooded stream and river channels, growing in sunny areas on sandy or rocky clay soils, often rooting among boulders, at 100–500 m elev. At the type locality the species is locally abundant, numbering ca. 200 shrubs, but absent to rare on nearby stretches of the river. The plants were growing around a flat rock basin that had been under ca. 0.5–1 m of water during the rainy season in August but completely exposed during the dry season in January. Plants were both flowering and fruiting. Scattered seeds with attached comas were floating at the margins of the water, indicative of dispersal by both wind and water.

Additional specimens examined:

CAMBODIA. Koh Kong: 126 m, 11°35'34"N 103°05'2"E, 4 February 2007, *C. Long et al. CL546* (P!). Thmor Bang District, ca. 5 km SW from the Thmor Bang Ranger Station, at river basin near the water fall of Tatai River, 346 m, 11°39'39.27"N 103°23'58.66"E, 26 December 2012, *H. Won et al. 8697* (PH!). Tatai river valley, 490 m, 11°49'28"N 103°32'26"E, 21 February 2003, *W. Campbell et al. WA203* (A!). Thma Baing District, Ruessei Chrum Commune, Stoeng Kroyang Village, 340 m, 11°39'39.2"N 103°24'0.5"E, 18 May 2010, *M. Newman et al. 2337* (E!). Thma Baing District, Ruessei Chrum Commune, 342 m, 11°39'39.2"N 103°23'58.7"E, 22 December 2008, *M. Newman et al. 2162* (E!).

Discussion

Of all species of Marsdenieae, *Sarcolobus cambogensis* most resembles *Sarcolobus borneensis* and *S. luzonensis*. All three have a shrubby, rheophytic habit and leaves narrower than other *Sarcolobus* species (Table 1). It is also similar to *Sarcolobus stenophyllus* (Gray 1862: 335) Forster (1992: 594), a shrubby (but not rheophytic) congener from Fiji. *Sarcolobus cambogensis* has leaves typical of *Sarcolobus*: discolorous with brochidodromous venation, slightly undulate and revolute margins, a weakly apiculate tip, and an attenuate base that grades into a short petiole (Fig. 3). *Sarcolobus cambogensis* has oblong corpuscula 380–520 × 130–190 μm (nearly three times as long as wide) and apically truncate gynostegia (Fig. 4), like other species of *Sarcolobus* (Forster 1991, 1992, 1993). Upon close inspection, its caudicles are quite weakly geniculate (a third *Sarcolobus* characteristic), but have a much lower length to width ratio than those of *S. borneensis* and *S. luzonensis* (Table 1, Fig. 4). Its caudicles are more alike in shape and orientation to *Gymnema sylvestre* Brown (1810a: 33) or perhaps *S. porcatus* Forster (1991: 353) (Forster 1991, Omlor, 1998). Molecular phylogenetic analysis confirms the inclusion of *Sarcolobus cambogensis* in *Sarcolobus* (Livshultz *et al.* in prep.).

TABLE 1. Comparison of key morphological and ecological characters of *Sarcolobus cambogensis*, *S. borneensis*, *S. luzonensis,* and *S. stenophyllus.* Key character differences are leaf shape, leaf width, presence of a distinguishable petiole, staminal corona, geniculate caudicles, and caudicle length to width ratio. Bolded characters are diagnostic of *Sarcolobus* (Forster 1993). Measurements of *Sarcolobus cambogensis* are ours, those of the three other species are from Forster (1992, 1993). *geniculation of caudicles obscure in *Sarcolobus cambogensis.*

	region	rheophytic (Fig. 2)	woody shrub	leaf shape	leaf length (mm)	leaf width (mm)	distinguishable petiole
Sarcolobus cambogensis	Cambodia	√	√	narrow elliptic	33–87	5–13	√
Sarcolobus borneensis	Borneo	√	√	linear	22–60	3–5	-
Sarcolobus luzonensis	Philippines	√	√	linear	25–65	2–5	-
Sarcolobus stenophyllus	Fiji	-	√	linear	30–100	2–6	√

TABLE 1. (Continued)

	corolla shape	corolline corona	staminal corona	**Apically truncate gynostegium (Fig. 4A)**	**narrow-oblong corpusculum**	**geniculate caudicles (Fig. 4B)**
Sarcolobus cambogensis	camp.-subrotate	-	√	√	√	*
Sarcolobus borneensis	subrotate	√	-	√	√	√
Sarcolobus luzonensis	camp.-subrotate	-	√	√	√	√
Sarcolobus stenophyllus	rotate	-	√	√	√	√

TABLE 1. (Continued)

	caudicle length to width ratio	fruit length (mm)	seed length (mm)	coma length (mm)
Sarcolobus cambogensis	1.8	28–46	3.8–6.3	8–14
Sarcolobus borneensis	3.6	35–50	?	?
Sarcolobus luzonensis	5.0	40–48	2.7–3	4–5
Sarcolobus stenophyllus	13	40–55	6–7	5–10

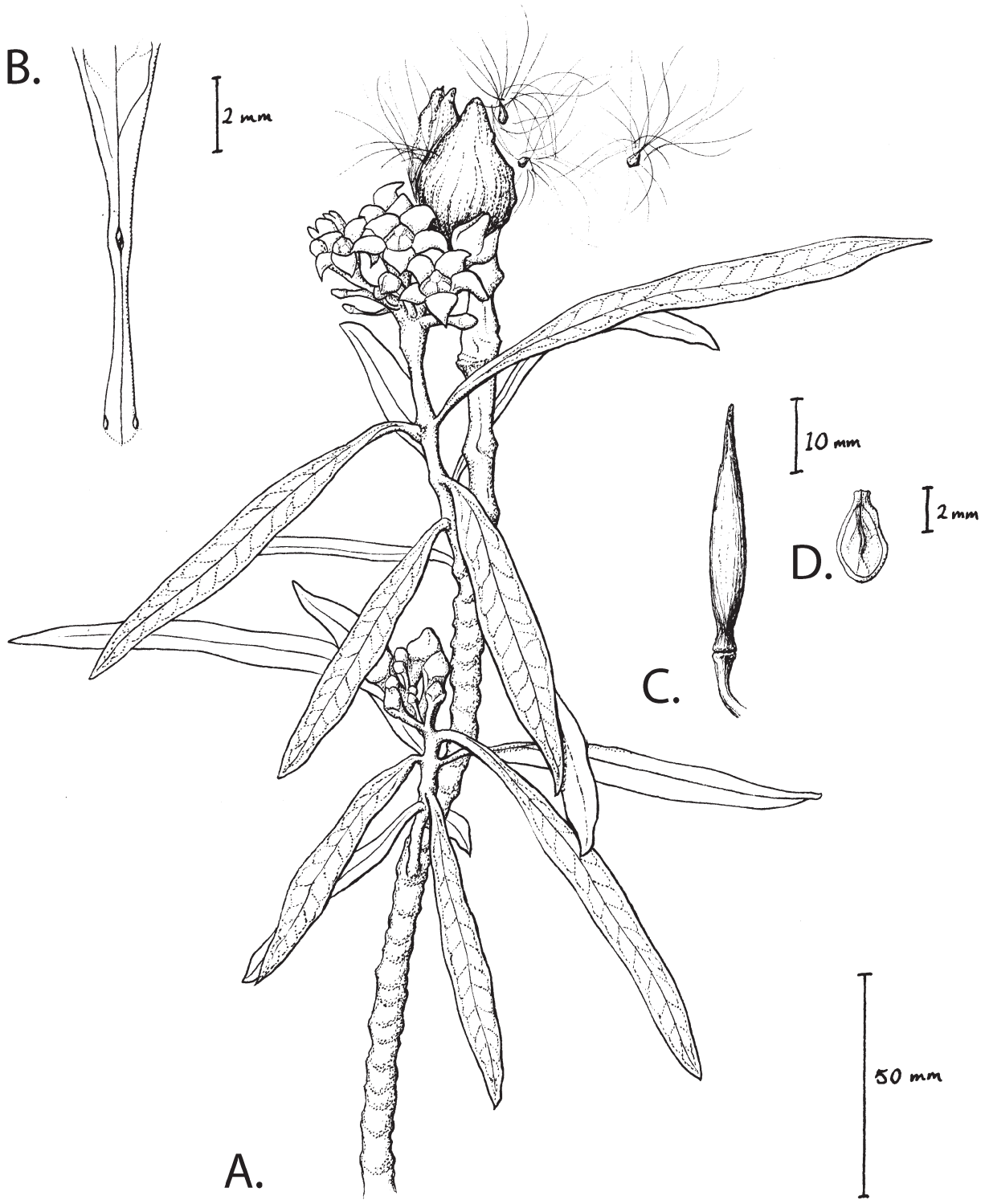

FIGURE 3. *Sarcolobus cambogensis*. **A.** Habit. **B.** Stipular and laminar colleters. **C.** Follicular fruit. **D.** Seed, without coma. (illustrations: Elizabeth McHone, A from H. Won photograph at type locality, B from *H. Won 6398*, C from *M. Newman 2337*, and D from *H. Won 8697*)

Sarcolobus cambogensis has a unique combination of characters that set it apart as a distinct species, including its prominent staminal corona, similar to that of *S. stenophyllus,* but absent in *S. borneensis* and *S. luzonensis*. Though similar, the leaves of *Sarcolobus borneensis* and *S. luzonensis* are more slender than those of *S. cambogensis* and have petioles barely distinguishable from the lamina or absent altogether. Leaves of *Sarcolobus cambogensis* are narrowly elliptic while those of *S. borneensis* and *S. luzonensis* are more accurately described as linear.

Given the distinctive morphology and the fact that *S. cambogensis* is disjunct from the three species it most resembles, it is clear that it is a new species of *Sarcolobus*. The implications of this finding for the evolution of rheophyt-

ism in *Sarcolobus* remain to be seen. The three rheophytic species may form a monophyletic group or, alternatively, it is possible that each has evolved rheophytism independently, its most recent ancestor a local species of mangrove or rainforest habitat. More extensive phylogenetic analyses and comparative morphological studies on the genus are necessary to answer this question.

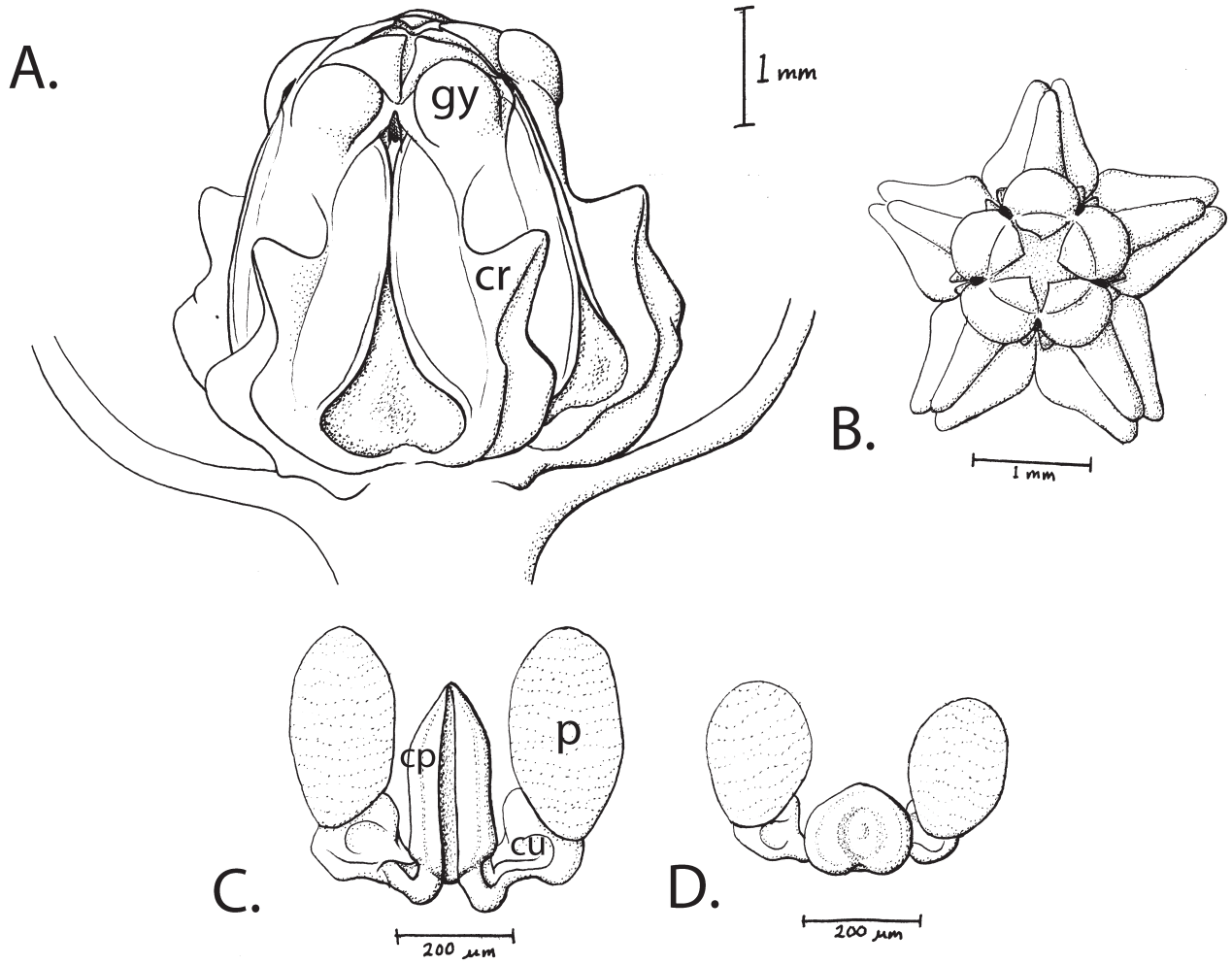

FIGURE 4. Flowers of *Sarcolobus cambogensis* **A**. Side view of gynostegium: prominent staminal corona (**cr**), apically truncate gynostegium (**gy**). **B.** Top view of gynostegium. **C.** Side view of pollinarium: narrow-oblong corpusculum (**cp**), wide, barely geniculate caudicles (**cu**), pollinium (**p**). **D.** Top view of pollinarium. (illustrations: Elizabeth McHone from *M. Newman 2162*)

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